2021 Joint PSAPS / CSAAPT / SPS Zone 9 Virtual Fall Meeting

Hosted by Lewis University

MEETING AGENDA

Time	Session ID	Session
9:00-9:05	A	Welcome
9:05-10:35	B	Invited Session 1
10:35-10:45		Break
10:45-11:45	C	Parallel Session 1
11:45-12:50	D	Lunch
12:50-2:20	E	Invited Session 2
2:20-2:30		Break
2:30-3:30	F	Parallel Session 2

9:00-9:05 Session A

Main Zoom Room

Welcome – Chris White (Lewis University)

9:05-10:35 Session B

Main Zoom Room

Session Chair – Joe Kozminski (Lewis University)

9:05-9:35 B01: Our Changing Climate: Impacts on Illinois

Donald Wuebbles (University of Illinois Urbana-Champaign)

The 2021 Nobel Prize in Physics being awarded to two pioneers in modeling of the Earth's climate system highlights the importance of climate change to the future of humanity. In addition, the recently released Sixth Assessment Report (AR6) of the UN's Intergovernmental Panel on Climate Change (IPCC) further strengthens what other assessments of the science have already been telling us for several decades: Climate change is happening now and it is happening throughout the world. This has been the warmest decade on record, but surface temperature is just one of many indicators of our changing climate. I recently co-led a special assessment of the impacts of climate change on the state of Illinois. Climate change is a major environmental challenge that is likely to affect many aspects of life in Illinois, ranging from human and environmental health to the economy. Illinois is already experiencing societal impacts from the changing climate and, as climate change progresses and temperatures continue to rise, these impacts are expected to increase over time. This report paints a stark picture of the changes in store for Illinois because of our changing climate, but it also depends on which pathway we follow in slowing down climate change. This presentation summarizes the changing climate in Illinois, its potential impacts on the people and ecosystems in Illinois, and how we can respond. I feel confident that we can slow climate change and reduce its magnitude, but it will take a concerted worldwide effort to greatly reduce the human-related emissions that are driving these changes. Taking action now to reduce emissions and to build resilience is critical for combatting climate change, and it can also lead to a more equitable and sustainable future.

9:35-10:05 B02: The issues, the challenges, and some of the resources to create more equitable and inclusive physics environments

Alexis Knaub (AAPT)

There is growing interest in physics and astronomy to create more equitable and inclusive environments that will support all to flourish and thrive. Even with this interest, it can be difficult to know what to do, what is already happening, and how to get involved. This talk will describe some of the issues and areas in physics where equity and inclusion needs improvement, as well as feature various resources and programmatic efforts from AAPT and APS that physics educators can be involved with in various capacities such as the Physics and Astronomy STEMM Equity Achievement (SEA) Change project.

10:05-10:35 B03: The Mysterious Growth of Cold Quasars

Allison Kirkpatrick (University of Kansas)

All galaxies host a supermassive black hole at their centers, at least a million times the mass of the Sun. Material falling onto these monsters can be as bright as the galaxy itself, or it may be lurking unseen behind thick blankets of dust. These monsters go through growth spurts and feeding frenzies that can greatly impact their host galaxies, possibly even terminating all nearby star formation. I will focus on the rare, anomalous Cold Quasars, which are some of the most luminous accreting black holes in the universe, and yet, surprisingly, their host galaxies have star formation rates of 1000 Msun/yr, casting doubt on whether black hole feedback impacts star formation at all. Finally, I will discuss how I incorporate black hole science into my introductory and upper level classes.

10:45-11:45 Session C

Session C01: PSAPS High Energy Physics
Zoom Breakout Room 1

Session Chair: Bryce Littlejohn (Illinois Tech)

10:45-10:57 C01.1: Tau electromagnetic energy loss and tau polarization for very high energy tau leptons

Diksha Garg (University of Iowa)

The neutrino interaction length scales with energy, and becomes comparable to Earth’s diameter above PeV energies. At such high energies, the tau’s short lifetime leads to energetic regenerated tau neutrino flux, $\nu_\tau\to\tau\to \nu_\tau$, within the Earth. The next generation of neutrino experiments aim to detect ultra-high energy neutrinos, and many of them rely on detecting either the regenerated tau neutrino, or the tau decay shower. Both of these signatures are affected by polarization of the tau through the energy distribution of the secondary particles produced from the tau’s decay. While $\tau’s produced in weak interactions are nearly 100\% polarized, it is expected that $\tau’s experience depolarization due to electromagnetic energy loss in the Earth. In this talk, we quantify the depolarization of $\tau’s in electromagnetic energy loss. Tau depolarization can be directly implemented in Monte Carlo simulations such as NuPyProp, TauRunner and other tau neutrino propagation codes.

10:57-11:09 C01.2: Silicon Module Testing for the Compact Muon Solenoid Forward Pixel Upgrade

Alexander Thielen (University of Illinois at Chicago)

In order to strengthen results of the Large Hadron Collider, higher luminosities will be used in future runs. This will result in larger particle flux and radiation to the Silicon Pixel Detector of the Compact Muon Solenoid. To maintain the precision of particle tracking, the detector must undergo an upgrade.

Each of the silicon modules must pass numerous quality assurance tests to ensure the accuracy in the path of tracked particles.

11:09-11:21 C01.3: Revisiting Combinatorial Ambiguities in Dilepton $\bar{t}t$ Event Topologies with Neural Networks

Zhongtian Dong (University of Kansas)

We revisit with machine learning algorithms the combinatorial problem in SUSY-like events with two invisible particles at the LHC. As a concrete example, we illustrate our procedure with the dilepton $t \bar t$ events. We first reproduce results using several existing methods and compare them against performance of various machine learning algorithms. In particular, we investigate performance of attention-based network, which exploits permutation symmetry in the problem. We then consider the general case when the underlying mass spectrum is unknown, and no kinematic endpoint information is available. We demonstrate that the efficiency for selecting the correct partition is greatly improved by utilizing the machine learning techniques."

11:21-11:33 C01.4: Investigation of CP-Violation in the Top-Higgs Yukawa Interaction via High-Energy Muon Collisions

Morgan Cassidy (University of Kansas)

The Standard Model of particle physics, though remaining a consistent theory with the discovery of the Higgs boson, fails to address several questions about nature, such as the accelerated expansion of the universe, dark matter, and the asymmetry of matter and anti-matter. Of interest, and a goal of particle physics, is to look for new interactions in order to provide explanation to these questions. This project studies a new source for CP-violating interactions via the top quark and Higgs through high-energy muon collisions. The signal processes include $ \mu\mu$ $\rightarrow$ $t\bar{t}h$, $ \mu\mu$ $\rightarrow$ $t\bar{t}h\nu\nu$, and $ \mu\mu$ $\rightarrow$ $t\bar{b}h\mu\nu$ decaying semi-leptonically, and are simulated using MadGraph5_aMC@NLO. A CP-Violating model is incorporated into the MadGraph5_aMC@NLO framework to account for a non-zero CP phase, unlike what is predicted in the Standard Model for the top-Higgs Yukawa interaction. The current focus studies kinematic distributions for a CP angle set at $\frac{\pi}{2}$ and $-\frac{\pi}{2}$. Looking forward, the signal processes will be set to decay hadronically and leptonically, and ultimately, this study looks to determine limits on the CP angle of the top-Higgs Yukawa interaction.

11:33-11:45 C01.5: Top-Higgs Interactive Simulations through MadGraph5_aMC@NLO and Future Investigations of Muon Colliders

Yanzhe Zhang (University of Kansas)

Particle colliders accelerate the discoveries and verification of the theoretical predictions of particles and the completeness of the Standard Model. Yet, the Standard Model still has its limitations including but not only the exclusion of gravity, the lack of solutions to the expanding universe in acceleration, and the problem of matter-antimatter asymmetry. Among all the fundamental particles within the Standard Model, top-quark and Higgs boson, as the most and second heaviest fundamental particles, are of particular interest. Therefore, we especially concentrate our focus on the top-Higgs interactions in a new type of proposed leptonic collider: the muon collider. Simulations of $\mu^+\mu^-$ collisions are done in both the Standard Model and a CP-violating model through MadGraph5_aMC@NLO and with smearing effects applied on the analyses of the cross-section variations and kinematic distributions as well as multiple cutoffs to find an analogy of the muon collider. With the study being further pursued, we hope to find more efficient cuts in order to maximize the signal-to-background significance and investigate the ability of a muon collider to detect CP violation in the top-Higgs interactions.

Session C02: PSAPS Condensed Matter Physics
Zoom Breakout Room 2

Session Chair: Nicholas Mauro (St. Norbert College)

10:45-10:57 C02.1: The Effect of RF Sputter Deposition on MgF2 Thin Films

Peadar McGrath (St. Norbert College)

Optical and physical properties of magnesium fluoride (MgF2) thin films were investigated. The films were grown on glass microscope slides using radio frequency magnetron sputter deposition. Thickness of the thin films were determined using data from x-ray reflectivity measurements. The stoichiometric ratios of the films were confirmed using measurements from energy dispersive x-ray spectroscopy. Values for the reflection and transmission coefficients were calculated from direct measurements of the intensities of a helium neon laser beam through the films and substrates. After preliminary measurements of physical properties, several films were annealed to various temperatures and the measurements were retaken. The relationship between thickness and optical properties was investigated, but the results were inconclusive due to the presence of absorption of light in the thin films, suggesting impurities in the film. These results will lead to a greater understanding of the effect of sputter deposition on optical properties of anti-reflective coatings, but further work will be necessary to minimize the impurities of the film and the light being absorbed.

10:57-11:09 C02.2: Analyzing Nanoscale Thermal Transport Using Time-resolved X-ray Diffraction

James Grammich (Northern Illinois University)

Classical models of thermal transport breakdown at lengthscales below a few microns in many materials. Time-resolved x-ray diffraction has been proposed as one method to investigate this regime of nanoscale thermal transport, especially inside semiconductor materials where other techniques can not penetrate or yield quantitative results. We benchmarked a new, portable, and fast open-source x-ray dynamical diffraction code (\emph{TRXD}) for strained crystals developed by DePaul University against an existing standard server-based closed-source calculation tool (\emph{GID_SL}, Grazing Incidence Diffraction for Superlattices). \emph{TRXD} is also validated against experimental x-ray peak lineshapes by convolving the calculation results with an appropriate instrumentation resolution function. \emph{TRXD} is shown to properly predict the long time-scale classical thermal behavior of a cooling semiconductor, while revealing discrepancies at the short time-scale where new nanoscale thermal transport models are under development. A new high-resolution x-ray diffraction data set is compared to a previously published low-resolution data set, and found to give the same result for delayed thermal transport in ultrafast laser-excited 100 nm metal film on a Gallium Arsenide crystal substrate.

11:09-11:21 C02.3: First Demonstration of AI-assisted automation of single crystal neutron diffraction

Leah Zimmer (St. Norbert College)

Single-crystal neutron diffraction experiments can provide insight into a material's atomic structure and the origin of a material's properties. Current methods of analyzing data from these experiments rely on Bragg peak recognition, signal extraction and multiple codes'; executions. This type of analysis is time-consuming and inefficient. Automated real-time analysis of the images and a common coding language would greatly increase the efficiency of single-crystal neutron diffraction experiments. We present the

first demonstration of machine-learning-assisted automated single-crystal neutron diffraction experiments at Oak Ridge National Laboratory. Real-time analysis will optimize the use of neutron beam time and more precisely reduce the data. We plan to integrate our demonstration into real-time analysis methods which will become the new analysis standard at the neutron-scattering user facility at Oak Ridge National Laboratory.

11:21-11:33 C02.4: A ruthenium oxide thermometer for dilution refrigerators operating down to 5 mK

Sean Myers (Purdue University)

At the lowest temperatures achieved in dilution refrigerators, ruthenium oxide resistance thermometers often saturate and therefore lose their sensitivity. In an effort to extend the range of such temperature sensors, we built a thermometer which maintains sensitivity to 5 mK. A key component of this thermometer is an in situ radio frequency filter which is based on a modern rf absorption material. We show that the use of such a filter is only effective when it is encased in the same rf-tight enclosure as the ruthenium oxide sensor. Our design delivers an attenuation level that is necessary to mitigate the effects of parasitic heating of a fraction of pW present in our circuit. Furthermore, we show that the likely origin of this parasitic heating is the black body radiation present within the experimental space of the refrigerator.

11:33-11:45 C02.5: Breakdown of the nu $=$ 1 integer quantum Hall state in a high mobility sample

Haoyun Huang (Purdue University)

The integer quantum Hall Wigner solid was recently observed in high mobility GaAs two-dimensional electron gas samples near filling factor nu $=$ 1. We performed large signal current-voltage characteristic measurements in the region of this phase. We observed well-defined breakdown behavior in the regions of both the integer quantum Hall Wigner solid and the Anderson insulator. To our surprise, we find that the critical current exhibits a monotonic dependence as the filling factor moves away from the center of the nu $=$ 1 plateau, even in the region of the Wigner solid. Therefore, it appears that the breakdown in the current-voltage characteristics measured along the nu $=$ 1 integer quantum Hall plateau does not differentiate the reentrant integer quantum Hall Wigner solid from the Anderson insulator.

*The work at Purdue was supported by the US DOE, Office of Basic Energy Sciences under the award DE-SC0006671. Sample growth efforts at Princeton University were supported by the National Science Foundation MRSEC Grant DMR-1420541 and the Gordon and Betty Moore Foundation Grant GBMF 4420.

Session C03: CSAAPT /SPS Zone 9 Contributed Session
Zoom Breakout Room 3

Session Chair: James Hofmann (Lewis University)

10:45-10:57 C03.1: Enhancing Physics Laboratory and Community Outreach Through 3D Printing

Peter Mbi, Joey Koenig, Matthew Mantia, and James Hofmann (Lewis University)

3-D printing is an advantageous skill to obtain. It allows one to create and design ideas into reality instantly. The printing process is sustainable and cost-effective. Utilizing 3-Dimensional printing in a physics laboratory provides lab equipment at an affordable cost compared to buying the original product. By designing and printing equipment, students can obtain a more advantageous understanding of their physics labs and courses at an affordable cost. This research discusses the benefits of 3-Dimensional printing for physics labs such optical diffraction and standing waves. Beyond the laboratory, 3-D printing can be beneficial for community outreach events and provide hands on experience for math and science courses ranging from elementary school to high school. This research also discusses community outreach demos for the Pythagoras Cup and Bernoulli's equation. By enhancing education with 3-Dimensional printing, students will gain a better understanding of foundational knowledge in the laboratory. Additionally, the community will benefit from enhanced hands-on demos of interesting physics principles.

10:57-11:09 C03.2: Exotic Fuels: The Direct Fusion Drive Engine

Marek Spader and Ryan Hooper (Lewis University)

The Direct Fusion Drive (DFD) is a theoretical propulsion system using exotic fuel types. It is designed to provide thrust to a rocket for spaceflight using fusion nuclear reactions. The nuclear reactions will be fueled using deuterium and helium three (D-(_^3)He). These fuels are specifically chosen because of their aneutronic nature. A nonhomogeneous magnetic field will be used to direct the fusion products to the exhaust port. This engine is compact, and depending on the need could be designed just as large as contemporary rockets or can be designed to be much more compact. Prior literature states that this technology could be used for travel in the immediate vicinity of Earth, for Mars missions, and for trans-Neptunian expeditions. Prior literature also indicates that this type of engine may be more powerful than conventional rockets. In this paper, a simulation of the DFD process is done using a modeling program called Geant4 by CERN. This allows us to manipulate many variables, most importantly the engine parameters, and determine the various outputs of the different engine configurations. The preliminary results gathered show a trend towards this confirmation with the specific impulse of the Direct Fusion Drive being measured at 718,000 s.

11:09-11:21 C03.3: Low-Cost 3D-Model of a Static Light Scattering System Design with an Arduino Based Sensor

Alexis Bibian, Michael Vargas, and Joseph Kozminski (Lewis University)

Light scattering is a phenomenon in which photons interact with particles in a medium and have their paths altered. Light scattering can provide insight on things like light interaction properties and the size of particles in a sample. Typically, expensive instruments need to be used to study scattering phenomena. The purpose of this experiment is to develop a compact, low-cost method to analyze the properties of light scattering in various solutions using 3D printed components, an Arduino-based photosensor, polarizing films, and a low-cost light source in the setup. The results of polarized light scattering studies and a study of the angular dependence of scattered light intensity will be presented in addition to the low cost set up. The results of polarized light scattering studies and a study of the angular dependence of scattered light intensity of the low cost, $150, set up will be presented and compared to the standard light scattering devices that usually cost several thousand dollars

11:21-11:36 C03.4: The Benefits and Challenges of Undergraduate Research at the High School Level

Michelle Sachtleben and Scott Howard (Downers Grove South High School)

There are many avenues for motivated students to hone their academic talents while still in high school but many of those opportunities can be specific and scripted. Downers Grove South has found success in developing a student research club that allows motivated, academically curious students to pursue a variety of research projects that build their skills as student researchers in a manner typical of college students including writing and presenting to peers as well as academic faculty. The experience, personal growth and confidence shown by these students has afforded students opportunities for scholarships, internships and college research. This presentation will highlight the challenges, successes and benefits of starting a research group at the high school level.

11:36-11:51 C03.5: Physics of Celestial Music

Antony Soosaleon (Mahatma Gandhi University)

Every astronomical body is associated with musical notes of a range of frequencies which we call it as Whistler waves. The physics of these waves is less understood and seems to be mysterious, but here I want discuss the mechanism of these musical notes and how they are generated by the astronomical bodies. With a unique formula we can calculate the range of frequencies of any celestial body if the necessary datas are available.

11:45-12:45 Session D
Lunch / Business Meetings

Main Zoom Room
Open for general networking

Breakout Room 1
PSAPS Business Meeting

Breakout Room 2
CSAAPT Business Meeting

Breakout Room 3
SPS Zone 9 Business Meeting

12:50-2:20 Session E Invited Session 2
Main Zoom Room

Session Chair – Chris White (Lewis University)

12:50-1:20 E01: Perspectives from the Inside and Outside - Advocating for Science and Science Policy

Jerry Blazey (Northern Illinois University)

As with any form of communication, advocacy for science and science policy requires identifying key audiences and opportunities. In this presentation, some of the main opportunities for advocacy with the Executive and Legislative Branches are identified and illustrated. As a preface and because of the tight coupling with advocacy opportunities, the Federal budget cycle is briefly reviewed. The speaker has participated in science advocacy and policy development from multiple perspectives as a member of the Department of Energy Office of High Energy Physics (2007-2010) and the White House Office of Science and Technology Policy (2011-2014) and with responsibility for University federal relations at Northern Illinois University.

1:20-1:50 E02: Novel platforms for emergent quasiparticles in quantum spin liquids

Arnab Banerjee (Purdue University)

Quantum dynamics can work in peculiar ways leading to a host of phenomena not seen in classical physics, which includes Dirac, Weyl and Majorana type excitations and fractionalized quasiparticles. These quasiparticles take a world of their own and can be used for new applications ranging from topological quantum computation and ultrasensitive sensors. In this talk, I will present the recent results on a quantum spin system, the transition-metal trihalides, where we observe such a host of exotic phenomena. I will particularly concentrate on $RuCl_3$ where bond-dependent frustration stabilizes a Kitaev type Ising interactions leading to a spectrum of Majorana Fermions. In a magnetic field, these fermions produce a spin gap below which the existence of a gapless edge current of Majorana fermions - indirect evidence of bulk non-abelian anyons - were experimentally seen. We performed inelastic scattering experiments to show how the excitations evolve which gives us critical insights into the nature of these spin excitations and future pathways to manipulate them.

1:50-2:20 E03: An Introduction to Argonne National Laboratory

Stephen Streiffer (Argonne National Laboratory)

For 75 years, Argonne National Laboratory has accelerated science and technology through pioneering discoveries in multiple fields of research and by technology innovations that are embraced by industry. We support the U.S. Department of Energy (DOE) mission with our programs in discovery science, energy and climate research and development, global security, and large-scale research facilities. In this talk, I will give a high-level overview of Argonne's S&T thrusts, with an emphasis on fundamental and materials physics research. I will also provide a summary of relevant educational and outreach programs that build off Argonne's activities in workforce development.

2:30-3:30 Session F Parallel Session 1

Session F01: PSAPS Nuclear and Astrophysics
Zoom Breakout Room 1

Session Chair: Joe Kozminski (Lewis University)

2:30-2:42 F01.1: Evaluating fitting models of the missing energy contribution of Ar and Ti nuclear shell orbitals using the E12-14-012 (e, e$\prime $ p) scattering experiment at Jefferson Lab

Zachary Jerzyk (St. Norbert College)

The Deep Underground Neutrino Experiment (DUNE) will probe CP-symmetry violation by observing neutrino and antineutrino oscillation rates, detect supernovae neutrinos, and potentially inform new grand unification theories by making the first observation of proton decay. DUNE will use a liquid argon time-projection chamber (LAr-TPC) detector; however, little work has been done on electron-nucleus scattering for isospin nonsymmetric atoms or neutrino-nucleus scattering for argon-40. In the Hall A experiment E12-14-012 at Jefferson Lab, the (e, e$\prime $ p) scattering cross sections of argon (N$=$22) and titanium (Z$=$22) were measured against a detailed Monte Carlo (MC) simulation. Various kinematical cuts were performed on the experimental data and MC for signal identification. Minimization was performed on each orbital's cross section as a function of missing energy against either a Gaussian (symmetric) or Maxwell-Boltzmann (nonsymmetric) distribution and dependence or independence of the function on the mean energy. In this talk, I will discuss how the initial fit models of argon and titanium were modified, how the quality of fit is evaluated, and how this will inform our error analysis on the argon and titanium proton spectral functions.

2:42-2:54 F01.2: Propagating Neutrinos and Charged Leptons Inside the Earth using nuPyProp

Sameer Patel (University of Iowa)

The design and development of new balloon and sub-orbital missions capable of detecting upward going extensive air showers caused by neutrino interactions inside the Earth rely on simulations to assess instrument sensitivity to UHE neutrinos. We introduce nuPyProp, which is a simple to use, Monte Carlo package designed to simulate and model UHE neutrino interactions and charged lepton energy loss inside the Earth. nuPyProp is a part of the nuSpaceSim simulation package, and it primarily generates lookup tables for $\nu_\tau\to \tau$ and $\nu_\mu\to \mu$ propagation. It allows for the user to choose from a subset of neutrino cross-section models and charged lepton photonuclear energy loss models, along with the flexibility to create \& use custom models for propagation. I will describe the simulation framework and discuss the impacts of using different models and two different energy loss propagation techniques - stochastic \& continuous on charged lepton exit probabilities and their outgoing energy distributions.

2:54-3:06 F01.3: Plasma Turbulence in the Local Cavity of the Interstellar Medium

Steven Spangler (University of Iowa)

The Interstellar Medium consists of matter in space between the stars. For decades, it has been known that the Local Interstellar Medium is dominated by a cavity that is approximately 500 light years in diameter. The physical state and origin of gas within this cavity remain topics for research. The state of turbulence in the cavity gas is also of interest, and radio observations of pulsars can diagnose this turbulence. The existence of ``pulsar arcs'' in radio spectra of pulsars are particularly useful in that they determine the distance to possible thin sheets of turbulent plasma. Recently, Reardon et al (Astrophysical Journal 904, 104, 2021) have measured pulsar arcs for the nearby pulsar J0437-4715. They obtain a precise value for the distance to the primary turbulent sheet of 293 light years (89.8 parsecs). This distance is consistent with the ``wall'' of the Local Cavity in that direction, and suggests that turbulence is generated in the interface between the Local Cavity and surrounding gas.

3:06-3:18 F01.4: Calculation of the actual values of linear and rotational velocity of the universe

Gh. Saleh (Saleh Research Centre)

According to big bang theory, the universe began to expand after the big bang, and this expansion is continued to this day and does not have stopped moving just yet. At the beginning of the big bang, the universe expanded more quickly and then reached a relative equilibrium and the objects are moving at their specific velocity relative to their position. In this paper we are going to find an equation that could explain the actual velocity of any celestial objects in the universe. Everything in the universe, from the smallest to the largest objects, is spherical, such as electrons, atoms, the moon, the earth, the sun, etc. So, the universe is also very likely to be spherical. By assuming the universe is spherical and based on conservation of Energy, we have written the equation for velocity of any celestial objects in the universe, which consists of two parts: a rotational part and a linear part. The value of these parts could be obtained by using the energy released in the Big Bang moment, Hubble’s law and Redshift/ Blueshift, etc. Based on these, we have derived a velocity-time equation that could explain the motion of any celestial objects from the big bang moment."

Session F02: PSAPS Quantum and Condensed/Soft Matter Physics
Zoom Breakout Room 2

Session Chair: Larry Lurio (Northern Illinois University)

2:30-2:42 F02.1: Building student research project capacity, optics offers many possibilities

Zach Simmons (Milwaukee School of Engineering)

Research-grade experiments in physics often require equipment complex and expensive enough to be out of reach for small institutions. One area of research and potential student projects well-suited to make the most of modest resources is optics. Experiments can be small and applications are myriad and often interdisciplinary. Also, equipment such as cameras and light sources have benefited from consumer advances and applications, becoming ever cheaper and more powerful. This work describes a project at MSOE to build student experiment capacity in optics. The specific project is the construction of an apparatus to measure an optical phenomenon called enhanced backscattering (EBS). EBS is well-suited as an example for this work as it is a simple apparatus that does not require a scientific camera and has varied applications, from liquid characterization to cancerous tissue discrimination. EBS also provides pedagogical opportunities to connect to numerical modeling techniques like Monte-Carlo simulation. Presentation will include construction of the apparatus, discussion of data acquisition enabled by open-source program micro-manager, and some initial experimental data.

2:42-2:54 F02.2: High Throughput Nuclear Resonance Time Domain Interferometry using Annular Slits

Marc Pavlik (Northern Illinois University)

Nuclear resonance time domain interferometry (NR-TDI) is used to study the slow dynamics of liquids (that do not require M\"{o}ssbauer isotopes) at atomic and molecular length scales. We employed the TDI method of using a stationary two-line magnetized \ce{^{57}Fe} foil as a source and a stationary single-line stainless steel foil analyzer. Our new technique of adding an annular slit in front of a single silicon avalanche photodiode (APD) detector enables a wide range of momentum transfers $\qty(\num{1}\text{ to }\SI{100}{\per \nano \meter})$ with a high count rate of up to $\SI{160}{\hertz}$ with a Δq resolution of $\SI{\pm1.7}{\per\nano \meter}$ at $q=\SI{14}{\per\nano \meter}$. The sensitivity of this method in determining relaxation times is quantified and discussed. The Kohlrausch--Williams--Watts (KWW) model was used to extract relaxation times for glycerol ranging from 2 to $\SI{600}{\nano \second}$. These relaxation times gives insight into the dynamics of the electron density fluctuations of glycerol as a function of temperature and momentum transfers.

2:54-3:06 F02.3: Multipartite Entanglement in the Disordered Quantum Ising Model

Jay Zou (Northwestern University)

Entanglement is a distinguishing property of quantum mechanics, offering fundamentally stronger correlations than classical physics. Entanglement entropy of a single subsystem in the disordered quantum Ising model is well understood, demonstrating a non-universal “area law” and a universal logarithmic term unique at quantum phase transitions. However, entanglement of multiple subsystems in interacting quantum systems remains a challenging open problem. Entanglement negativity and mutual information are promising ways to quantify entanglement across multiple subsystems. In this project, we explore entanglement negativity and mutual information between two subsystems of length ℓ separated by distance d. Both are calculated by a numerical implementation of the asymptotically exact strong disorder renormalization group method. As an application, we identify the requirements of constant, universal, distance-independent entanglement between two subsystems. Our numerical results are further supported by analytic results, providing strict universal upper-bounds for multipartite entanglement based on gap-size statistics. Our findings reveal universal principles of how entanglement connects distant subsystems with potential implications for quantum communication.

3:06-3:18 F02.4: What does a protein network look like? A solution from network inference and the inverse Ising problem

Jenny Liu (Northwestern University)

Advances in protein structure determination have created increasing interest in the dynamics of folded proteins and their role in function, further increasing the importance of molecular dynamics simulations.

To analyze these large datasets, proteins are often modeled as networks to take advantage of well-developed methods from network science. Protein networks are often constructed from correlative measures. Yet, in the field of network science, it has been demonstrated that solving the inverse problem is required to identify the interactions. Thus, we apply this inverse approach to the dynamics of protein dihedral angles, a system of internal coordinates that avoids the structural alignment issue in hinge-like proteins. Focusing on the adhesion protein, FimH, we show that our method identifies networks that are related to underlying physical interactions and are robust across replicates. We extend our approach to Siglec-8, an immune adhesion protein, and the SARS-CoV-2 spike protein. Due to the differences in the networks constructed by correlation and by solving the inverse problem, there are also downstream differences in network analysis. We apply community detection to identify flexible and rigid regions that regulate collective motion relevant to protein function.

3:18-3:30 F02.5: Electric Vehicle Emissions by State

Logan Hennes

Transportation is the economic sector with the highest greenhouse gas (GHG) emissions in the United States. Dramatic transition is needed in all vehicle markets to alternative fuels by 2035 to reach deep decarbonization in all sectors. Over 1.9 million plug-in electric vehicles (PEVs) have been sold in the United States through June 2021. PEVs include both all-electric battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs). Using the grid mix for each subregion provided by the EPA, we determined the emission rates from the electric grid in each state from 2010 to 2020. We also incorporated vehicle efficiency and vehicle sales by state to calculate the emissions generated per mile and the total historical emissions generated by state and nationally."

Session F03 SPS Zone 9 Session
Zoom Breakout Room 3

Session Chair: SPS Zone 9 Leadership

2:30-2:42 F03.1: Fully Leptonic Charmonium Decays using the PANDA Detector at FAIR

Grant Lattery (Grinnell College) and Em Garvey and Mark Lattery (University of Wisconsin Oshkosh)

The Proton-Antiproton at Darmstadt Germany (PANDA) fixed-target particle experiment consists of the High Energy Storage Ring (HESR) and the PANDA particle physics detector. Anti-protons (p bar) circulating in the HESR strike essentially fixed protons (p) within the PANDA detector. At select beam energies, these collisions produce charmonium (c cbar) particles, which quickly decay to lighter particles. The PANDA detector uses a sophisticated set of tracking chambers and particle-identification subdetectors to (1) measure the momenta and energies of all final-state particles, and (2) reconstruct charmonium decay chains. In this talk, we discuss initial Monte Carlo studies of the charmonium formation and decay process, p pbar → ψ(1S) → e+ e- and μ+ μ-, to test the PandaRoot software framework and evaluate PANDA detector performance. Special attention is given to the electromagnetic calorimeter and muon detection system. Detailed large-sample charmonium studies provide sensitive tests of Quantum Chromodynamics (QCD), the current most-productive model of the strong interaction. The PANDA experiment is currently under construction at the Facility for Antiproton and Ion Research (FAIR). Authors (alphabetically): Em Garvey (UW Oshkosh); Grant Lattery (Grinnell College); Dr. Mark Lattery (UW Oshkosh), PANDA Collaboration member. Funded in part by the U.S. Department of Education TRIO program.

2:42-3:30: F03.2: SPS Chapter Design Challenge
Collaborative Engineering Project: Wildfire Prevention Drone

Oscar Peterson-Veatch, William Murillo, Tatenda Nyoni (Augustana College)

In this meeting I will present every chapter in zone 9 with a challenge: To create the most complete, best proposal they can for the design, creation, and implementation of a Wildfire Prevention Drone. In the Spring Zone 9 meeting we will reconvene and vote on the best proposal. The winning proposal will become the plan our zone adopts for a multi-chapter collaboration to actually create this drone and bring it into reality for the world.

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